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December 9, 2014
Job No. 14-0577

Mr. Jim Hager
21314 Calhoun Road
Monroe, Washington, 98272

Re: Geotechnical Engineering Investigation
Hager Property
16691 Currie Road
Monroe, Washington

Dear Mr. Hager:

As requested, GeoTest Services, Inc. is pleased to submit this report summarizing the results of our geotechnical engineering evaluation for the above-referenced project. The purpose of this evaluation was to investigate general subsurface conditions beneath the site from which conclusions and recommendations for project design could be formulated. Specifically, our scope of services included the following tasks:

- Exploration of soil and groundwater conditions underlying the site by observing a total of 8 exploration test pits to evaluate subsurface conditions.
- Laboratory testing on representative samples in order to classify and evaluate the engineering characteristics and infiltration potential of the soils encountered.
- Provide this written report containing a description of subsurface conditions, test pit logs, and findings and recommendations pertaining to critical areas, seismic design, site preparation and earthwork, fill and compaction, wet weather earthwork, foundation recommendations, concrete slab-on-grade construction, foundation and site drainage, stormwater design recommendations, preparation and geotechnical consultation and construction monitoring.

PROJECT DESCRIPTION

The project site is located at 16691 Currie Road in Monroe, Washington and consists of a partially developed, approximately 6.6 acre property. GeoTest understands that a new residential subdivision is planned for the property that is likely to include 26 to 28 new single-family residences. GeoTest is not aware of specific construction plans, but we anticipate that the residences may include up to 2 stories with slab-on-grade floors and wood frame construction. Structural loads are anticipated to be relatively light.

GeoTest anticipates that new drive paths and sidewalks will be established as part of project development. GeoTest understands that project development will not require new ponds or stormwater detention facilities, although it is expected that elements of Low Impact Development will be used to treat and dispose of roof and driveway runoff.

SITE CONDITIONS

This section discusses the general surface and subsurface conditions observed at the project site at the time of our field investigation. Interpretations of the site conditions are based on the results of our review of available information, site reconnaissance, subsurface explorations, laboratory testing, and our experience in the project vicinity.

Surface Conditions

The site is generally flat, with less than a few feet of elevation differential across the site. Vegetation on the site consists of short grass and/or pasture with poplar and other generally deciduous trees along the property margins. We understand that the property was previously utilized as a golf driving range and there are associated parking areas and a building located on the south end of the property.

A drainage swale is present along the north margin of Currie Road and cuts across the southwest corner of the property. Rapidly flowing water was observed in the swale at the time of our site visit

Subsurface Soil Conditions

Subsurface conditions were explored by advancing 8 exploration test pits (TP-1 though TP-8) on November 10, 2014. The explorations were advanced to depths of between 6 and 7 feet below ground surface (BGS) using a subcontracted excavator. Excavations could not be advanced below 7 feet BGS due to running and caving of soils below the groundwater table.

The on-site subsurface soils generally consisted of approximately 4 to 9 inches of topsoil over 1 to 2 feet of fine grained Silty Alluvium (stiff, tan to grey, moist sandy, silt) over coarse grained Sandy Alluvium (medium dense to very dense, tan to grey, wet to saturated, very gravelly, sand to very sandy, gravel) to the base of all explorations.

See the attached Site and Exploration Map (Figure 2) and the Log of Test Pits (Figures 5 through 8) for more information regarding the approximate locations of the exploration pits and subsurface soil conditions encountered.

General Geologic Conditions

Geologic information for the project site was obtained from the interactive *Geologic Map of Washington State*, published by the Washington State Department of Natural Resources (DNR) and *the Geologic Map of the Maltby Quadrangle, Snohomish and King Counties, Washington,* by the U.S. Geological Survey *(Minard, J.P., 1985)*. According to the referenced maps, subsurface soils within the project area consist of Quaternary Alluvium (Qa) to the north and Advance Glacial Outwash (Transitional Beds) ($Qga_{(t)}$) along the southern margin of the site.

Soils defined as alluvium typically consist of sand and gravel deposited along rivers and streams. This unit is described by Minard (1985) as consisting of silts, clays and fine sands near the surface with coarser sand and gravel at depth. Transitional Beds are described by Minard (1985) as clays silts and sands deposited prior to the placement of Advance Glacial Outwash. The interactive DNR map, however, labels the Transitional

Beds unit also as Advance Glacial Outwash. Advance Outwash typically consists of clean sands and gravels deposited by meltwater from, and then advanced over by, glacial ice.

For this report we have interpreted the subsurface soils to be either Silty Alluvium or Sandy Alluvium. However, due to the apparent high density of the coarse grained sands and gravels encountered at depth, these soils could be interpreted as an Advance Outwash-like deposit between the Transitional Beds and Advance Glacial Outwash.

Groundwater

At the time of our subsurface investigation in November of 2014, slight to moderate groundwater seepage was encountered at depths of 2 to 3 feet below existing site grades at all explorations except TP-4 and TP-6. At all explorations, seepage became moderate to rapid below 4 to 6 feet BGS. We anticipate this seepage to be indicative of a region wide groundwater table. Heavily mottled zones observed in TP-3 and TP-7 suggests that seasonal groundwater may raise to as high as 1.75 to 2 feet BGS.

The groundwater conditions reported on the exploration logs are for the specific locations and date indicated, and therefore may not necessarily be indicative of other locations and/or times. Groundwater levels are not static and groundwater conditions will vary depending on local subsurface conditions, precipitation, changes in site use, both on and off site, and other factors.

CONCLUSIONS AND RECOMMENDATIONS

Based upon evaluation of the data collected during this investigation, it is our opinion that subsurface conditions at the site are suitable for the proposed construction of the development, provided the recommendations contained herein are incorporated into the project design.

Elevated groundwater was observed at the project site. This groundwater has the potential to complicate excavations onsite, including the placement of site utilities. Construction during the generally drier summer and fall months would be anticipated to reduce, but not eliminate, potential construction complications due to high groundwater.

Geologic Hazards and Recommended Mitigation

The site is flat and does not meet the criteria established in the Monroe Municipal Code for slope or erosion hazards and no specific mitigations for these hazards are required for this project

Site development is anticipated to include a Washington State Department of Ecology Construction Storm Water General Permit to mitigate the erosion potential of soils exposed during construction or site grading activities. In order to meet the criteria established by the Department of Ecology, an erosion control plan consistent with the governing municipal standards and best management practices will be required for this project. The contractor will be responsible for implementing the erosion control plan as established in the plans and specifications approved by the governing municipality for the project.

Seismic Hazard

Portions of the project site are located within a mapped liquefaction hazard area. The mapped potential for liquefaction is considered moderate to high throughout the central and northern portions of the lot and very low along the southern portion. We interpret these classifications to be due to alluvial soils being mapped throughout the north and central portions of the lot with Transitional Beds to the south. Alluvial soils are generally considered to be at greater risk of liquefaction due to typically lower densities. Dense Advance Outwash and fine grained Transitional Beds are generally considered to be at lower risk of liquefaction due to their higher densities and/or higher silt and clay content.

Liquefaction is a process through which unconsolidated soil loses strength during a seismic event. Intense vibratory shaking can decrease soil shear strength through the disruption of grain-to-grain soil contact and an increase in the soil pore pressure. A soil is liquefied when the majority of the soil weight is supported by the pore pressure. Liquefaction can result in soil deformations and settlement of structures. Areas that are liquefiable typically include those areas underlain by low density sands or silts with high ground water conditions.

Geotest's experience with other properties in the area suggests a low liquefaction potential. The on-site explorations did, however, encounter an elevated ground water table in what we interpret to be dense alluvial soils. Based on regional conditions, encountered subsurface soil conditions, and the presence of an elevated groundwater table, it is our opinion that the liquefaction potential for this site is low to moderate under a design level earthquake. It is assumed that mitigation of liquefaction through deep foundations is not feasible due to the construction costs.

In the absence of deep foundations or similar ground improvement techniques, GeoTest recommends that the structural engineer incorporate additional reinforcing steel to "stiffen" the foundations so that if settlement occurs, the foundations can settle as a unit and reduce the amount of differential settlement that can occur under seismic conditions. The addition of structural steel will not address the regional liquefaction potential that underlies this property, but it will help to reduce the amount of damage to floor slab and foundation areas that can occur during a seismic event. This approach requires an acceptance of risk by the Owner that some settlement is possible during a design seismic event. If the Owner is unwilling to accept the risks of post-liquefaction settlement, a deep foundation system should be considered. GeoTest will require additional subsurface data if deep foundations are required for this project.

We recommend that a representative from our office be allowed to review civil and structural plans during project development to help ensure these recommendations are appropriately incorporated into the project design.

Site Preparation and Earthwork

The portions of the site to be occupied by the proposed building foundations or pavements should be prepared by removing existing topsoil, fill, relic topsoil and loose/soft, upper portions of the native soil.

Prior to the placement of structural fill, the exposed subgrade under all areas should be recompacted to a dense and unyielding condition and proof rolled with a loaded dump truck, large self-propelled vibrating roller, or equivalent piece of equipment applicable to the size of the excavation. The purpose of this effort is to identify possible loose or soft soil deposits and recompact the soil exposed during site excavation activities.

Proof rolling should be carefully observed by qualified geotechnical personnel. Areas exhibiting significant deflection, pumping, or over-saturation that cannot be readily compacted should be overexcavated to firm soil. Overexcavated areas should be backfilled with compacted granular material placed in accordance with subsequent recommendations for structural fill. During periods of wet weather, proof rolling could damage the exposed subgrade. Under these conditions, qualified geotechnical personnel should observe subgrade conditions to determine if proof rolling is feasible.

Fill and Compaction

Structural fill used to obtain final elevations for footings, soil-supported floor slabs or pavements must be properly placed and compacted. In general, any suitable, non-organic, predominantly granular soil may be used for fill material provided the material is properly moisture conditioned prior to placement and compaction, and the specified degree of compaction is obtained. Excavated site material containing topsoil, wood, trash, organic material, or construction debris will not be suitable for reuse as structural fill and should be properly disposed offsite or placed in nonstructural areas.

Reuse of Onsite Soil

The silty and organic nature of the near-surface topsoil and Silty Alluvium prevents it from being used in structural fill applications. The generally clean Sandy Alluvium (sand and gravel) encountered generally below 2 feet BGS could be used be used in structural fill applications provided it is moisture conditioned and compacted, and if allowed for use in the project plans and specifications. Much of the Sandy Alluvium, however, was observed to be below the groundwater table. Soils excavated from below the groundwater table are anticipated to be over optimum moisture content and will require a moisture conditioning program to lower the in place moisture to within 2 percent of the optimum moisture content, as determined by ASTM D 1557.

Soils containing more than approximately 5 percent fines are considered moisture sensitive, and are very difficult to compact to a firm and unyielding condition when over the optimum moisture content by more than approximately 2 percent. The optimum moisture content is that which allows the greatest dry density to be achieved at a given level of compactive effort.

Imported Structural Fill

We recommend that imported structural fill consist of clean, well-graded sandy gravel, gravelly sand, or other approved naturally occurring granular material (pit run) with at least 30 percent retained on the No. 4 sieve, or a well-graded crushed rock. Structural fill for dry weather construction may contain on the order of 10 percent fines (that portion passing the U.S. No. 200 sieve) based on the portion passing the U.S. No. 4 sieve. Soil containing more than about 5 percent fines cannot consistently be compacted to a dense, non-yielding condition when the water content is greater than optimum.

Accordingly, we recommend that imported structural fill with less than 5 percent fines be used during wet weather conditions. Due to wet weather or wet site conditions, soil moisture contents could be high enough that it may be very difficult to compact even "clean" imported select granular fill to a firm and unyielding condition. Soils with over-optimum moisture contents should be either scarified and dried back to more suitable moisture contents during periods of dry weather or removed and replaced with fill soils at a more suitable range of moisture contents.

Backfill and Compaction

Structural fill should be placed in horizontal lifts 8 to 10 inches in loose thickness and thoroughly compacted. All structural fill placed under load bearing areas should be compacted to at least 95 percent of the maximum dry density, as determined using test method ASTM D 1557. Structural fill should be placed in horizontal lifts 8 to 10 inches in loose thickness and thoroughly compacted.

All structural fill placed under load bearing areas should be compacted to at least 95 percent of the maximum dry density, as determined using test method ASTM D1557. The top of the compacted structural fill should extend outside all foundations and other structural improvements a minimum distance equal to the thickness of the fill. We recommend that compaction be tested periodically throughout the fill placement.

Wet Weather Earthwork

The upper portions of the on-site soils are moisture sensitive. It is our experience that near-surface silty soils are particularly susceptible to degradation during wet weather. As a result, it may be difficult to control the moisture content of the site soils during the wet season. If construction is accomplished during wet weather, we recommend that structural fill consist of imported, clean, well-graded sand or sand and gravel as described above. If fill is to be placed or earthwork is to be performed in wet weather or under wet conditions, the contractor may reduce soil disturbance by:

- Limiting the size of areas that are stripped of topsoil and left exposed
- Accomplishing earthwork in small sections
- Limiting construction traffic over unprotected soil
- Sloping excavated surfaces to promote runoff
- Limiting the size and type of construction equipment used
- Providing gravel "working mats" over areas of prepared subgrade
- Removing wet surficial soil prior to commencing fill placement each day
- Sealing the exposed ground surface by rolling with a smooth drum compactor or rubber-tired roller at the end of each working day
- Providing upgradient perimeter ditches or low earthen berms and using temporary sumps to collect runoff and prevent water from ponding and damaging exposed subgrades.

Temporary and Permanent Slopes

Actual construction slope configurations and maintenance of safe working conditions, including temporary excavation stability, should be the responsibility of the contractor, who is able to monitor the construction activities and has direct control over the means and methods of construction. All applicable local, state, and federal safety codes should be followed. All open cuts should be monitored during and after excavation for any evidence of instability. If instability is detected, the contractor should flatten the side slopes or install temporary shoring.

Temporary excavations in excess of 4 ft should be shored or sloped in accordance with Safety Standards for Construction Work Part N, WAC 296-155-657.

Temporary unsupported excavations in the Alluvial soils encountered onsite should be classified as a Type C soil according to WAC 296-155-657 and may be sloped as steep as 1.5H:1V (Horizontal: Vertical). All soils encountered are classified as Type C soil in the presence of groundwater seepage. Flatter slopes or temporary shoring may be required in areas where groundwater flow is present and unstable conditions develop.

Temporary slopes and excavations should be protected as soon as possible using appropriate methods to prevent erosion from occurring during periods of wet weather.

We recommend that permanent cut or fill slopes be designed for inclinations of 2H:1V or flatter. Permanent cuts or fills used in detention ponds, retention ponds, or earth slopes intended to hold water should be 3H:1V or flatter. All permanent slopes should be vegetated or otherwise protected to limit the potential for erosion as soon as practical after construction.

Seismic Design Considerations

The Pacific Northwest is seismically active and the site could be subject to ground shaking from a moderate to major earthquake. Consequently, moderate levels of earthquake shaking should be anticipated during the design life of the project, and the proposed structure should be designed to resist earthquake loading using appropriate design methodology.

Site Class Definition

For structures designed using the seismic design provisions of the 2012 International Building Code, the underlying alluvial soils interpreted to underlie the site within the upper 100 feet classifies as Site Class D according to 2010 ASCE -7 Standard – Table 20.3-1, Site Class Definitions. The corresponding values for calculating a design response spectrum for the assumed soil profile type is considered appropriate for the site.

Please use the following values for seismic structural design purposes:

Conterminous 48 States – 2012 International Building Code
Zip Code 98272
Central Latitude = 47.85271, Central Longitude = -121.00879

Short Period (0.2 sec) Spectral Acceleration

Maximum Considered Earthquake (MCE) Value of S_s = 1.241 (g)
Site Response Coefficient, F_a = 1.004 (Site Class D)
Adjusted spectral response acceleration for Site Class D, $S_{MS} = S_s \times F_a = 1.245$ (g)
Design spectral response acceleration for Site Class D, $S_{DS} = 2/3 \times SM_s = 0.830$ (g)

One Second Period (1 sec) Spectral Acceleration

Maximum Considered Earthquake (MCE) Value of S_1 = 0.469 (g)
Site Response Coefficient, F_v = 1.531 (Site Class D)
Adjusted spectral response acceleration for Site Class D, $S_{M1} = S_1 \times F_v = 0.718$ (g)
Design spectral response acceleration for Site Class D, $S_{D1} = 2/3 \times SM_1 = 0.479$(g)

Foundation Support and Settlement

We recommend that all topsoil, relic topsoil, organic and silty portions of the native site soil be removed below footing and slab areas. Based upon our explorations, 1 to 2 feet of topsoil and Silty Alluvium may need to be removed to reach suitable bearing conditions.

Foundation support for the proposed improvements may be provided by continuous or isolated spread footings founded on the proof-rolled or recompacted, undisturbed, firm and unyielding Sandy Alluvium (clean sand and gravel) or on properly compacted structural fill placed directly over Sandy Alluvium. Alternatively, localized overexcavations could be backfilled to the design footing elevation with controlled density fill (CDF) or foundations may be extended to bear on undisturbed Sandy Alluvium.

In areas requiring overexcavation to competent Sandy Alluvium, the limits of the overexcavation should extend laterally beyond the edge of each side of the footing a distance equal to the depth of the fill. If CDF is used to backfill the overexcavation, the limits of the overexcavation need only extend a nominal distance beyond the width of the footing.

All continuous and isolated spread footings should be founded a minimum of 18 inches below the lowest adjacent final grade for freeze/thaw protection.

Allowable Bearing Capacity

Assuming the above foundation support criteria are satisfied, continuous or isolated spread footings founded directly on the Sandy Alluvium (clean sand and gravel), compacted structural fill, or CDF placed directly over firm Sandy Alluvium may be proportioned using a maximum net allowable soil bearing pressure of 2,000 pounds per square ft (psf). The term "net allowable bearing pressure" refers to the pressure that can be imposed on the soil at foundation level resulting from the total of all dead plus live loads, exclusive of the weight of the footing or any backfill placed above the footing. The net allowable bearing pressure may be increased by one-third for transient wind or seismic loads.

Foundation Settlement

Settlement of shallow foundations depends on foundation size and bearing pressure, as well as the strength and compressibility characteristics of the underlying soil. Assuming construction is accomplished as previously recommended and for the maximum allowable soil bearing pressure recommended above, we estimate the total settlement of building foundations should be less than about 1 inch and differential settlement between two adjacent load-bearing components supported on competent soil should be less than about one half the total settlement. The soil response to applied stresses caused by building and other loads is expected to be predominantly elastic in nature, with most of the settlement occurring during construction as loads are applied.

Concrete Slabs-on-Grade

Conventional slab-on-grade floor construction is considered feasible for the site. Floor slabs may be supported on properly prepared native subgrade or on structural fill placed over properly prepared native soil. New floor slabs should not be founded on topsoil, existing fill, or loose native soils. Prior to placement of structural fill, the native soil should be proof-rolled as recommended in the *Site Preparation and Earthwork* section of this report.

We recommend that interior concrete slab-on-grade floors be underlain by a minimum of 6 inches of compacted, clean, free-draining gravel with less than 3 percent passing the U.S. Standard No. 200 sieve (based on a wet sieve analysis of that portion passing the U.S. Standard No. 4 sieve). The purpose of this layer is to provide uniform support for the slab, provide a capillary break, and act as a drainage layer. To help reduce the potential for water vapor migration through floor slabs, a continuous 10-mil minimum thickness polyethylene sheet with tape-sealed joints should be installed below the slab to serve as an impermeable vapor barrier. The vapor barrier should be installed and sealed in accordance with the manufactures instructions.

The American Concrete Institute (ACI) guidelines suggest that the slab may either be poured directly on the vapor barrier or on a granular curing layer placed over the vapor barrier depending on conditions anticipated during construction. We recommend that the architect or structural engineer specify if a curing layer should be used. If moisture control within the building is critical, we recommend that the vapor barrier be observed by a representative of GeoTest to confirm that openings have been properly sealed. Use of a curing layer is generally only recommended during drier months of the year and/or when limited rain is expected during the slab-on-grade construction process. If the slab will be constructed during the wet season, exposed to rain after construction or the site may be potentially wet, we do not recommend the use of curing layer as excessive moisture emissions through the slab may occur.

Exterior concrete slabs-on-grade, such as sidewalks, may be supported directly on undisturbed native or on properly placed and compacted structural fill; however, long-term performance will be enhanced if exterior slabs are placed on a layer of clean, durable, well-draining granular material.

Foundation and Site Drainage

To reduce the potential for groundwater and surface water to seep into interior spaces we recommend that an exterior footing drain system be constructed around the perimeter of new building foundations as shown in the Typical Footing and Wall Drain Section, Figure 3. The drain should consist of a minimum 4-inch diameter perforated PVC pipe, surrounded by a minimum 12 inches of filtering media with the discharge sloped to carry water to a suitable collection system. The filtering media may consist of open-graded drain rock wrapped by a nonwoven geotextile fabric (such as Mirafi 140N or equivalent) or a graded sand and gravel filter. The drainage backfill should be carried up the back of the wall and contain less than 3 percent by weight passing the U.S. Standard No. 200 sieve (based on a wet sieve analysis of that portion passing the U.S. Standard No. 4 sieve). The invert of the footing drain pipe should be placed at approximately the same elevation as the bottom of the footing or 12 inches below the adjacent floor slab grade, whichever is deeper, so that water will not seep through walls or floor slabs. The footing drain should discharge to an approved drain system and include cleanouts to allow periodic maintenance and inspection.

Positive surface gradients should be provided adjacent to the proposed building to direct surface water away from the foundation and toward suitable drainage facilities. Roof drainage should not be introduced into the perimeter footing drains, but should be separately discharged directly to the stormwater collection system or other appropriate outlet. Pavement and sidewalk areas should be sloped and drainage gradients should be maintained to carry all surface water away from the building towards the local stormwater collection system. Surface water should not be allowed to pond and soak into the ground surface near buildings or paved areas during or after construction. Construction excavations should be sloped to drain to sumps where water from seepage, rainfall, and runoff can be collected and pumped to a suitable discharge facility.

Resistance to Lateral Loads

The lateral earth pressures that develop against retaining walls will depend on the method of backfill placement, degree of compaction, slope of backfill, type of backfill material, provisions for drainage, magnitude and location of any adjacent surcharge loads, and the degree to which the wall can yield laterally during or after placement of backfill. If the wall is allowed to rotate or yield so the top of the wall moves an amount equal to or greater than about 0.001 to 0.002 times its height (a yielding wall), the soil pressure exerted will be the active soil pressure. When a wall is restrained against lateral movement or tilting (a nonyielding wall), the soil pressure exerted is the at-rest soil pressure. Wall restraint may develop if a rigid structural network is constructed prior to backfilling or if the wall is inherently stiff.

We recommend that yielding walls under drained conditions be designed for an equivalent fluid density of 30 pounds per cubic ft (pcf) for structural fill in active soil conditions. Nonyielding walls under drained conditions should be designed for an equivalent fluid density of 50 pcf for structural fill in at-rest conditions. Design of walls should include appropriate lateral pressures caused by surcharge loads located within a horizontal distance equal to or less than the height of the wall. For uniform surcharge pressures, a uniformly distributed lateral pressure equal to 35 percent and 50 percent of the vertical surcharge pressure should be added to the lateral soil pressures for yielding and nonyielding walls, respectively. GeoTest assumes that retaining walls or below-grade structures will not extend below the groundwater table. If walls or structures extend below the water table, GeoTest should be contacted so that we may provide lateral earth pressures for submerged conditions.

Passive earth pressures developed against the sides of building foundations, in conjunction with friction developed between the base of the footings and the supporting subgrade, will resist lateral loads transmitted from the structure to its foundation. For design purposes, the passive resistance of well-compacted fill placed against the sides of foundations may be considered equivalent to a fluid with a density of 250 pounds per cubic ft. The recommended value includes a safety factor of about 1.5 and is based on the assumption that the ground surface adjacent to the structure is level in the direction of movement for a distance equal to or greater than twice the embedment depth. The recommended value also assumes drained conditions that will prevent the buildup of hydrostatic pressure in the compacted fill. Retaining walls should include a drain system constructed in general accordance with the recommendations presented in the *Foundation and Site Drainage* section of this report. In design computations, the upper 12 inches of passive resistance should be neglected if the soil is not covered by floor slabs or pavement. If future plans call for the removal of the soil providing resistance, the passive resistance should not be considered.

An allowable coefficient of base friction of 0.30, applied to vertical dead loads only, may be used between the underlying native soils or imported granular structural fill and the base of the footing. If passive and frictional resistance are considered together, one half the recommended passive soil resistance value should be used since larger strains are required to mobilize the passive soil resistance as compared to frictional resistance. We do not recommend increasing the coefficient of friction to resist seismic or wind loads.

Pavement Subgrade Preparation

Selection of a pavement section is typically a compromise between higher initial cost and lower maintenance on one side, and lower initial cost, with more frequent maintenance and less time before an overlay or other maintenance if necessary, on the other. For this reason, we recommend that the owner participate in the selection of a pavement section for the site. Site grading plans should include provisions for sloping of the subgrade soils in proposed pavement areas, so that passive drainage of the pavement section(s) can proceed uninterrupted during the life of the project.

GeoTest does not recommend placing new pavements on existing pavements, topsoil, existing fill, or loose native soils. New pavement sections should be installed over stripped, compacted, and/or otherwise firm and unyielding subgrades. It is our opinion that on-site near surface native soils are particularly susceptible to degradation during wet weather due to elevated fines contents and potential for elevated groundwater. To protect against degradation that would otherwise require over-excavation of loose or yielding soils, we recommend a minimum 12 inch thick "working mat" of structural fill be placed over prepared native grades in areas of anticipated construction traffic. We recommend other areas be left un-stripped and unprepared as long as feasible.

This "working mat" can be incorporated into the pavement section as appropriate. If work on the pavement section is to be conducted during the generally wet winter months, we recommend woven geotextile fabric (Mirafi 500X or performance equivalent) be placed over the native soils, below the gravel "working mat".

Utilities

It is important that utility trenches be properly backfilled and compacted to reduce cracking or localized loss of foundation, slab, or pavement support. It is anticipated that excavations for new shallow underground utilities will be in stiff sandy silts or sands and gravels.

Trench backfill in improved areas (beneath structures, pavements, sidewalks, etc.) should consist of structural fill as defined earlier in this report. Outside of improved areas, trench backfill may consist of re-used native fill provided it can be compacted to the project specifications. Trench backfill should be placed and compacted in general accordance with the recommendations presented in the *Fill and Compaction* section of this report.

Surcharge loads on trench support systems due to construction equipment, stockpiled material, and vehicle traffic should be included in the design of any anticipated shoring system. The contractor should implement measures to prevent surface water runoff from entering trenches and excavations. In addition, vibration as a result of construction activities and traffic may cause caving of the trench walls.

Actual trench configurations are the responsibility of the contractor. All applicable local, state, and federal safety codes should be followed. All open cuts should be monitored by the contractor during excavation for any evidence of instability. If instability is detected, the contractor should flatten the side slopes or install temporary shoring. If groundwater or groundwater seepage is present, and the trench is not properly dewatered, the soil within the trench zone may be prone to caving, channeling, and running. Trench widths under wet or saturated conditions may be substantially wider than under dewatered conditions.

Utility Trench Backfill Considerations

The near surface, Silty Alluvium will have elevated silt contents, is considered moisture sensitive, and is unlikely to be able to be reused in structural fill applications. The majority of the underlying Sandy Alluvium excavated from the site will be fine to medium sand with varying amounts of gravel. These soils are suitable for use as backfill material provided they are placed at or near optimum moisture contents. It should be noted, however, that GTS encountered shallow ground water in all of our exploration locations. GTS anticipates that soil below the water table will consist of saturated Sandy Alluvium that will not be suitable for backfill without significant moisture conditioning of these soils.

Utility Trench Base Support

There is a potential that utility trenches excavated below the groundwater table could experience a "quick" condition. A quick condition develops when the seepage pressure exceeds the resisting pressure. In this case, it would be the upwards vertical flow of water exceeding the unit weight of the soils at the bottom of the trench. The potential for a quick condition to develop is based on the hydraulic head difference between the water table level and the trench bottom and the unit weight of the surrounding soils.

If a quick condition does develop within utility trenches, it will be necessary to add quarry spall rock to the bottom of the trench during the excavation process. The quarry spall rock will add weight to the saturated sands and provide resistance against hydrostatic forces. If quick conditions develop in a lateral direction (i.e., running sand), mitigating the differential forces will be more difficult and will likely require that the water table be temporarily lowered to below the depth of the excavation.

Dewatering Considerations

Based on our previous experience, ground water elevations seasonally vary and can raise or lower several feet. Typically, groundwater elevations are highest in the late winter and early spring months, and lowest in late summer or early fall. Ground water elevations vary with season, adjacent site land usage, and recent rainfall.

When feasible, GeoTest recommends that utility trenching occur during late summer or early fall, when the water table is at its lowest elevation. Even if excavations occur during seasonal lows, it is likely that dewatering may have to occur. Based on our experience, it is likely that ground water will be controlled by using sump pumps during trench excavations or through the use of well points placed along the trench alignment. It is, however, the Contractor's responsibility to provide a suitable dewatering plan based on the type and depth of the excavation and the ground water elevation during construction.

Stormwater Design Recommendations

From the explorations excavated at the site, seven representative soil samples, obtained from above observed groundwater elevations, were selected and mechanically tested for grain size distribution and interpretation according to the ASTM soil size distribution test procedure (ASTM D422). Long term design infiltration rates have been obtained using the simplified approach in conjunction with soil grain size analysis, as outlined in the Washington State Department of Ecology *2012 Stormwater Management Manual for Western Washington* (Stormwater Manual), Section 3.3, and are reproduced in Table 1 below.

TABLE 1
Test Pit Soil Sample Infiltration Rates
2012 DOE Stormwater Management Manual, Simplified Approach, Section 3.3

Exploration	Sample Depth (ft)	Unit	Classification (USCS)	K_{sat} Initial Uncorrected Rate (in/hr)	Corrected K_{sat} Rate (in/hr)
TP-1	1.0	Alluvium	GP	104.5	26.3
TP-2	0.5	Alluvium	ML	1.7	0.43
TP-2	1.5	Alluvium	GW	93.1	23.5
TP-6	0.5	Alluvium	ML	0.6	0.15
TP-6	1.5	Alluvium	ML	0.5	0.13
TP-6	3.0	Alluvium	GP	97.5	24.6
TP-7	1.25	Alluvium	SP-SM	34.1	8.6

Note: The listed corrected Ksat rate above can be used as estimated long-term (design) infiltration rates per the simplified approach in the Stormwater Manual.
Correction Factors Used: CFv = 0.7, CFt = 0.4, CFm = 0.9
D10 and D60 estimated as 0.001 and 0.01 mm, respectively, when not obtained from the standard sieve set.

In the simplified approach (Section 3.3.4) the long-term design infiltration rate is derived by applying correction factors for site variability, test method and degree of influent control to prevent siltation and bio-buildup to the measured saturated hydraulic conductivity (K_{sat}) from the ASTM 422 grain size analysis.

After correction, the Silty Alluvium, typically encountered just below the topsoil throughout the site, is estimated to have a long term infiltration rate of 0.15 to 0.43 in/hr. The generally clean Sandy Alluvium encountered at depth is estimated to have a long term infiltration rate of between 8.6 and 26.3 in/hr using the methodology presented in the 2012 Stormwater Manual. It should be noted that the above referenced infiltration rate for the Sandy Alluvium **do not** account for saturated in-situ conditions.

Adequate amounts of separation between the base of infiltrations facilities and groundwater must be maintained at all stormwater facilities. At the time of our subsurface explorations, groundwater seepage was encountered as shallow as 2 feet BGS. *Suitable separation between conventional infiltration facilities and groundwater conditions does not appear feasible at the site.*

We do not recommend that conventional infiltration systems be utilized onsite and we do not recommend the above infiltration rates be utilized without additional correction to account for the observed high groundwater. GeoTest understands that project development will not require new ponds or stormwater detention facilities, although it is expected that elements of Low Impact Development (LID) will be used to treat and dispose of roof and driveway runoff. Use of LID techniques in conjunction with a mounding analysis may allow for facilities to be constructed with a reduced amount of groundwater separation. GTS will require additional design information from the Civil Engineer to determine the amount of vertical separation between LID facilities and groundwater conditions. We are available to assist with groundwater mounding analysis and the design of LID systems upon request.

Stormwater Treatment Capacity

Cation Exchange Capacity (CEC), organic content and pH tests were performed by Northwest Agricultural Consultants on two samples collected during this investigation from above the groundwater table. A copy of the laboratory test results is attached at the end of this report. A summary of the laboratory test results is presented in Table 2 below.

Table 2
Testing of Treatment Capacity Parameters

Test Pit Number	Sample Depth (Feet)	Unit	pH (unitless)	CEC (meq/100g)	Organic Content (percent)
TP-2	1.5	Alluvium	5.7	7.8	1.95
TP-7	1.25	Alluvium	5.3	7.4	2.52

The Department of Ecology *Stormwater Management Manual for Western Washington* (Ecology), SSC-6 *Soil Physical and Chemical Suitability for Treatment* states that the Cation Exchange Capacity (CEC) of the treatment soil must be greater than or equal to 5 milliequivalents CEC/100g dry soil. SSC-6 also recommends a minimum organic content of 1 percent of the dry weight.

Although samples above meet the minimum standards of SSC-6, they are not suitable for treatment purposes per SSC-4 *Soil Infiltration Rate/Drawdown Time* due to their high Ksat (initial) rates. Per SSC-4, soils used for treatment purposes should have a Ksat (initial) of 9 in/hr or less. The samples above exhibited Ksat (initial) rates of 93.1 and 34.1 in/hr.

Conceivably, excavated Sandy Alluvium could be amended to have properties recommended in the Stormwater Manual for an amended soil. Amendment could include the addition of higher fines soils, such as the Silty Alluvium, to reduce the Ksat (initial), and the addition of mulch or other admixtures to elevate the cation exchange capacity and/or organic content of the native soil. It should be noted that it has been historically difficult to obtain a uniformly blended amended soil by using conventional construction equipment to mix on-site soils and imported materials. On-site amended soil would also require additional testing of the amended soil to confirm compliance with Ecology-recommended soil properties. GTS is available to perform additional laboratory testing as part of an expanded scope of services if the soil is to be amended. Alternatively, the Owner may elect to import amended soils with the desired properties for planned treatment facilities.

Based on our review of the Snohomish County Aquifer Recharge/Wellhead Protection Area Map dated October 1, 2007, the subject site is not located within a well head protection zone.

Geotechnical Consultation and Construction Monitoring

We recommend that geotechnical construction monitoring services be provided. These services should include observation by geotechnical personnel during fill placement/compaction activities and subgrade preparation operations to verify that design subgrade conditions are obtained beneath the proposed building. We also recommend that periodic field density testing be performed to verify that the appropriate degree of compaction is obtained. The purpose of these services would be to observe compliance with the design concepts, specifications, and recommendations of this report, and in the event subsurface conditions differ from those anticipated before the start of construction, provide revised recommendations appropriate to the conditions revealed during construction. GeoTest Services would be pleased to provide these services for you.

GeoTest Services is also available to provide a full range of materials testing and special inspection during construction as required by the local building department and the International Building Code. This may include specific construction inspections on materials such as reinforced concrete, reinforced masonry, and structural steel. These services are supported by our fully accredited materials testing laboratory.

USE OF THIS REPORT

GeoTest Services has prepared this report for the exclusive use of Jim Hager and his design consultants for specific application to the design of the proposed development to be located at 16691 Currie Road in Monroe, Washington. Use of this report by others or for another project is at the user's sole risk. Within the limitations of scope, schedule, and budget, our services have been conducted in accordance with generally accepted practices of the geotechnical engineering profession; no other warranty, either express or implied, is made as to the professional advice included in this report.

Our site explorations indicate subsurface conditions at the dates and locations indicated. It is not warranted that they are representative of subsurface conditions at other locations and times. The analyses, conclusions, and recommendations contained in this report are based on site conditions to the limited depth of our explorations at the time of our exploration program, a brief geological reconnaissance of the area, and review of published geological information for the site. We assume that the explorations are representative of the subsurface conditions throughout the site during the preparation of our recommendations. If variations in subsurface conditions are encountered during construction, we should be notified for review of the recommendations of this report, and revision of such if necessary. If there is a substantial lapse of time between submission of this report and the start of construction, or if conditions change due to construction operations at or adjacent to the project site, we recommend that we review this report to determine the applicability of the conclusions and recommendations contained herein.

The earthwork contractor is responsible to perform all work in conformance with all applicable WISHA/OSHA regulations. GeoTest Services, Inc. should not be assumed to be responsible for job site safety on this project, and this responsibility is specifically disclaimed.

We appreciate the opportunity to provide geotechnical services on this project and look forward to assisting you during the construction phase. If you have any questions or comments regarding the information contained in this report, or if we may be of further service, please call.

Respectfully Submitted,
GeoTest Services, Inc.

State of Washington Licensed Geologist
Engineering Geologist 2945
Justin Brooks

Edwardo A. Garcia State of Washington 40819 Registered Professional Engineer
12-9-14

Justin Brooks, L.E.G.
Engineering Geologist

Edwardo Garcia, P.E.
Project Geotechnical Engineer

Attachments:	Figure 1	Vicinity Map
	Figure 2	Site and Exploration Plan
	Figure 3	Typical Footing and Wall Drain Section
	Figure 4	Soil Classification System and Key
	Figures 5-8	Exploration Logs
	Figures 9-10	Grain Size Test Data

REFERENCES

Interactive Geologic Map of Washington State. Online interactive services provided by the Washington State Department of Natural Resources, viewed 5-12-14.

Minard, J.P., 1985, Geologic map of the Maltby quadrangle, Snohomish and King Counties, Washington: U.S. Geological Survey, Miscellaneous Field Studies Map MF-1746, scale 1:24,000

Washington State Department of Ecology Water Quality Program. August 2012. *Stormwater Management Manual for Western Washington*. Publication Number 12-10-030.

REPORT LIMITATIONS AND GUIDELINES FOR ITS USE[1]

Subsurface issues may cause construction delays, cost overruns, claims, and disputes. While you cannot eliminate all such risks, you can manage them. The following information is provided to help:

Geotechnical Services are Performed for Specific Purposes, Persons, and Projects

At GeoTest our geotechnical engineers and geologists structure their services to meet specific needs of our clients. A geotechnical engineering study conducted for a civil engineer may not fulfill the needs of an owner, a construction contractor or even another civil engineer. Because each geotechnical engineering study is unique, each geotechnical engineering report is unique, prepared solely for the client. No one except you should rely on your geotechnical engineer who prepared it. And no one – not even you – should apply the report for any purpose or project except the one originally contemplated.

Read the Full Report

Serious problems have occurred because those relying on a geotechnical engineering report did not read it all. Do not rely on an executive summary. Do not read selected elements only.

A Geotechnical Engineering Report is Based on a Unique Set of Project-Specific Factors

GeoTest's geotechnical engineers consider a number of unique, project-specific factors when establishing the scope of a study. Typical factors include: the clients goals, objectives, and risk management preferences; the general nature of the structure involved its size, and configuration; the location of the structure on the site; and other planned or existing site improvements, such as access roads, parking lots, and underground utilities. Unless GeoTest, who conducted the study specifically states otherwise, do not rely on a geotechnical engineering report that was:

- not prepared for you,
- not prepared for your project,
- not prepared for the specific site explored, or
- completed before important project changes were made.

Typical changes that can erode the reliability of an existing geotechnical engineering report include those that affect:

- the function of the proposed structure, as when it's changed, for example, from a parking garage to an office building, or from a light industrial plant to a refrigerated warehouse,
- elevation, configuration, location, orientation, or weight of the proposed construction,
- alterations in drainage designs; or
- composition of the design team; the passage of time; man-made alterations and construction whether on or adjacent to the site; or by natural alterations and events, such as floods, earthquakes or groundwater fluctuations; or project ownership.

Always inform GeoTest's geotechnical engineer of project changes – even minor ones – and request an assessment of their impact. *Geotechnical engineers cannot accept responsibility or liability for problems that occur because their reports do not consider developments of which they were not informed.*

[1]Information in this document is based upon material developed by ASFE, Professional Firms Practicing in the Geosciences(asfe.org)

Subsurface Conditions Can Change

This geotechnical or geologic report is based on conditions that existed at the time the study was performed. Do not rely on the findings and conclusions of this report, whose adequacy may have been affected by: the passage of time; by man-made events, such as construction on or adjacent to the site; or by natural events, such as floods, earthquakes, or groundwater fluctuations. Always contact GeoTest before applying the report to determine if it is still relevant. A minor amount of additional testing or analysis will help determine if the report remains applicable.

Most Geotechnical and Geologic Findings are Professional Opinions

Our site exploration identifies subsurface conditions only at those points where subsurface tests are conducted or samples are taken. GeoTest's engineers and geologists review field and laboratory data and then apply their professional judgment to render an opinion about subsurface conditions throughout the site. Actual subsurface conditions may differ – sometimes significantly – from those indicated in your report. Retaining GeoTest who developed this report to provide construction observation is the most effective method of managing the risks associated with anticipated or unanticipated conditions.

A Report's Recommendations are *Not* Final

Do not over-rely on the construction recommendations included in this report. Those recommendations are not final, because geotechnical engineers or geologists develop them principally from judgment and opinion. GeoTest's geotechnical engineers or geologists can finalize their recommendations only by observing actual subsurface conditions revealed during construction. GeoTest cannot assume responsibility or liability for the report's recommendations if our firm does not perform the construction observation.

A Geotechnical Engineering or Geologic Report may be Subject to Misinterpretation

Misinterpretation of this report by other design team members can result in costly problems. Lower that risk by having GeoTest confer with appropriate members of the design team after submitting the report. Also, we suggest retaining GeoTest to review pertinent elements of the design teams plans and specifications. Contractors can also misinterpret a geotechnical engineering report. Reduce that risk by having GeoTest participate in pre-bid and preconstruction conferences, and by providing construction observation.

Do not Redraw the Exploration Logs

Our geotechnical engineers and geologists prepare final boring and testing logs based upon their interpretation of field logs and laboratory data. To prevent errors of omissions, the logs included in this report should never be redrawn for inclusion in architectural or other design drawings. Only photographic or electronic reproduction is acceptable; but recognizes that separating logs from the report can elevate risk.

Give Contractors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can make contractors liable for unanticipated subsurface conditions by limiting what they provide for bid preparation. To help prevent costly problems, give contractors the complete geotechnical engineering report, but preface it with a clearly written letter of transmittal. In that letter, consider advising the contractors that the report was not prepared for purposes of bid development and that the report's accuracy is limited; encourage them to confer with the GeoTest and/or to conduct

[1]Information in this document is based upon material developed by ASFE, Professional Firms Practicing in the Geosciences(asfe.org)

additional study to obtain the specific types of information they need or prefer. A pre-bid conference can also be valuable. Be sure contractors have sufficient time to perform additional study. Only then might you be in a position to give contractors the best information available, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions. In addition, it is recommended that a contingency for unanticipated conditions be included in your project budget and schedule.

Read Responsibility Provisions Closely

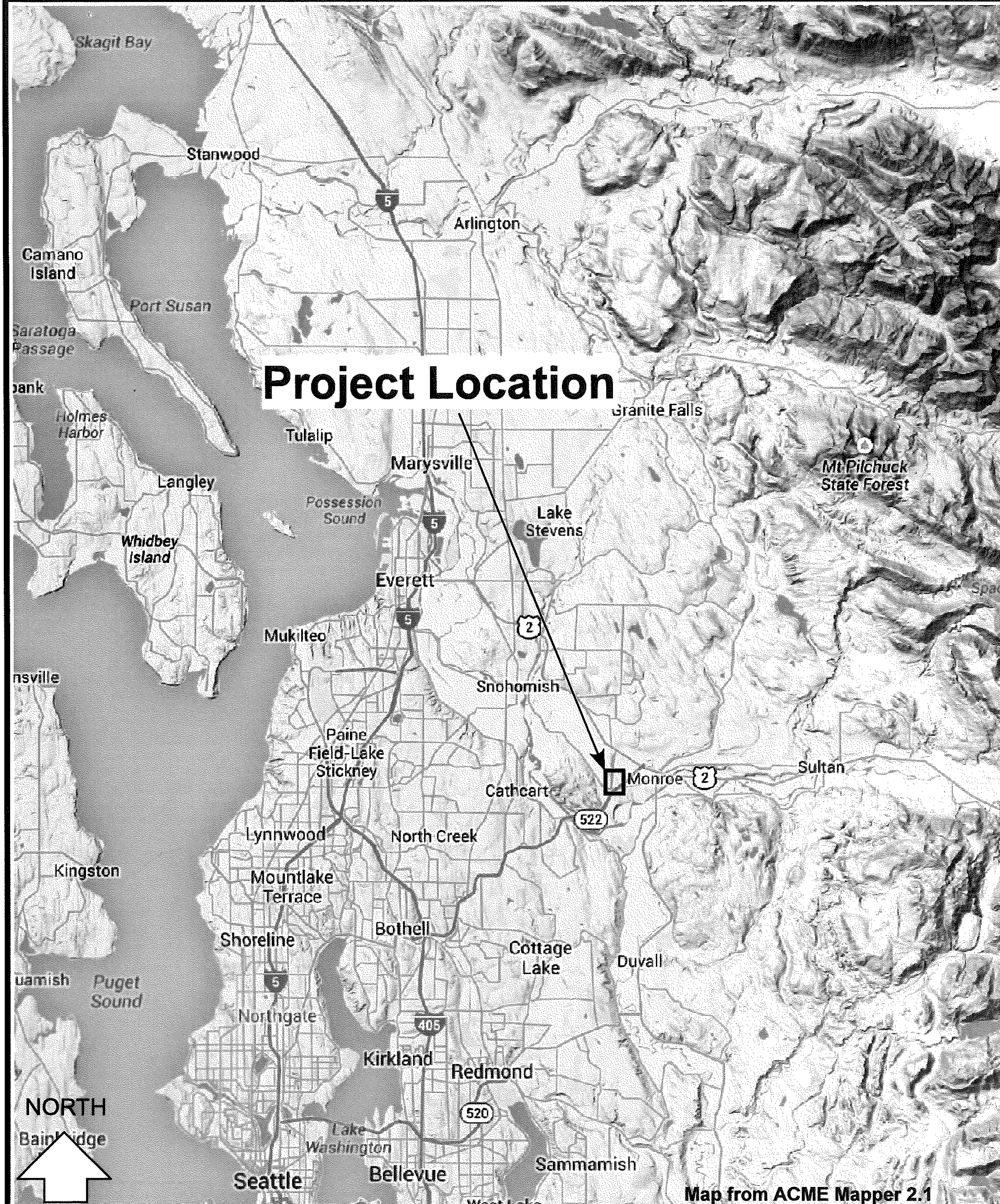
Some clients, design professionals, and contractors do not recognize that geotechnical engineering or geology is far less exact than other engineering disciplines. This lack of understanding can create unrealistic expectations that can lead to disappointments, claims, and disputes. To help reduce risk, GeoTest includes an explanatory limitations section in our reports. Read these provisions closely. Ask questions and we encourage our clients or their representative to contact our office if you are unclear as to how these provisions apply to your project.

Environmental Concerns Are Not Covered in this Geotechnical or Geologic Report

The equipment, techniques, and personnel used to perform an environmental study differ significantly from those used to perform a geotechnical or geologic study. For that reason, a geotechnical engineering or geologic report does not usually relate any environmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated containments, etc. If you have not yet obtained your own environmental information, ask your geotechnical consultant for risk management guidance. Do not rely on environmental report prepared for some one else.

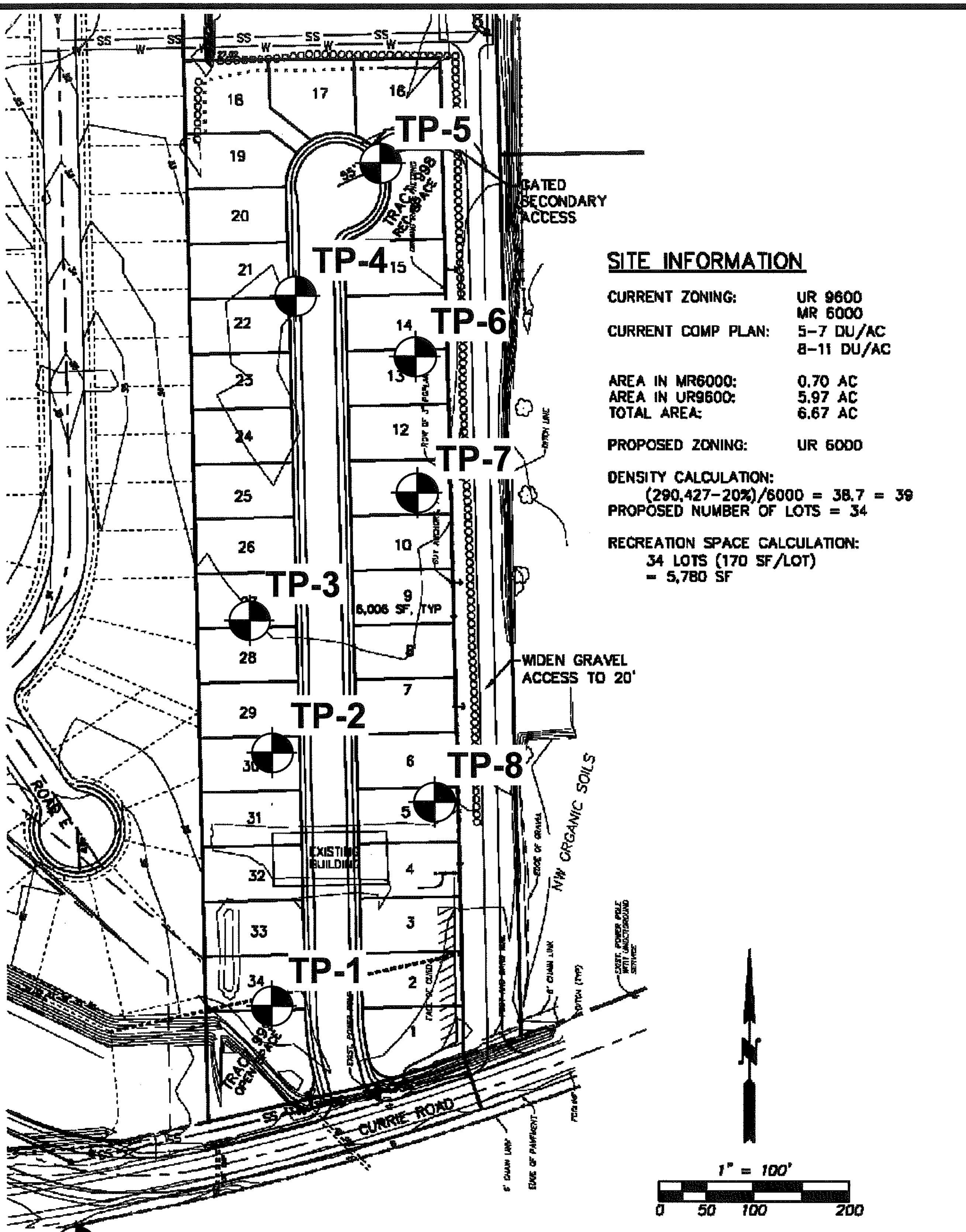
Obtain Professional Assistance to Deal with Biological Pollutants

Diverse strategies can be applied during building design, construction, operation, and maintenance to prevent significant amounts biological pollutants from growing on indoor surfaces. Biological pollutants includes but is not limited to molds, fungi, spores, bacteria and viruses. To be effective, all such strategies should be devised for the express purpose of prevention, integrated into a comprehensive plan, and executed with diligent oversight by a professional biological pollutant prevention consultant. Because just a small amount of water or moisture can lead to the development of severe biological infestations, a number of prevention strategies focus on keeping building surfaces dry. While groundwater, water infiltration, and similar issues may have been addressed as part of this study, the geotechnical engineer or geologist in charge of this project is not a biological pollutant prevention consultant; none of the services preformed in connection with this geotechnical engineering or geological study were designed or conducted for the purpose of preventing biological infestations.



GEOTEST SERVICES, INC.
741 Marine Drive
Bellingham, WA 98225
phone: (360) 733-7318
fax: (360) 733-7418

Date: 11-13-14	By: JB	Scale: none	Project 14-0577
VICINITY MAP **HAGER PROPERTY** **16691 CURRIE ROAD** **MONROE, WASHINGTON**			Figure 1

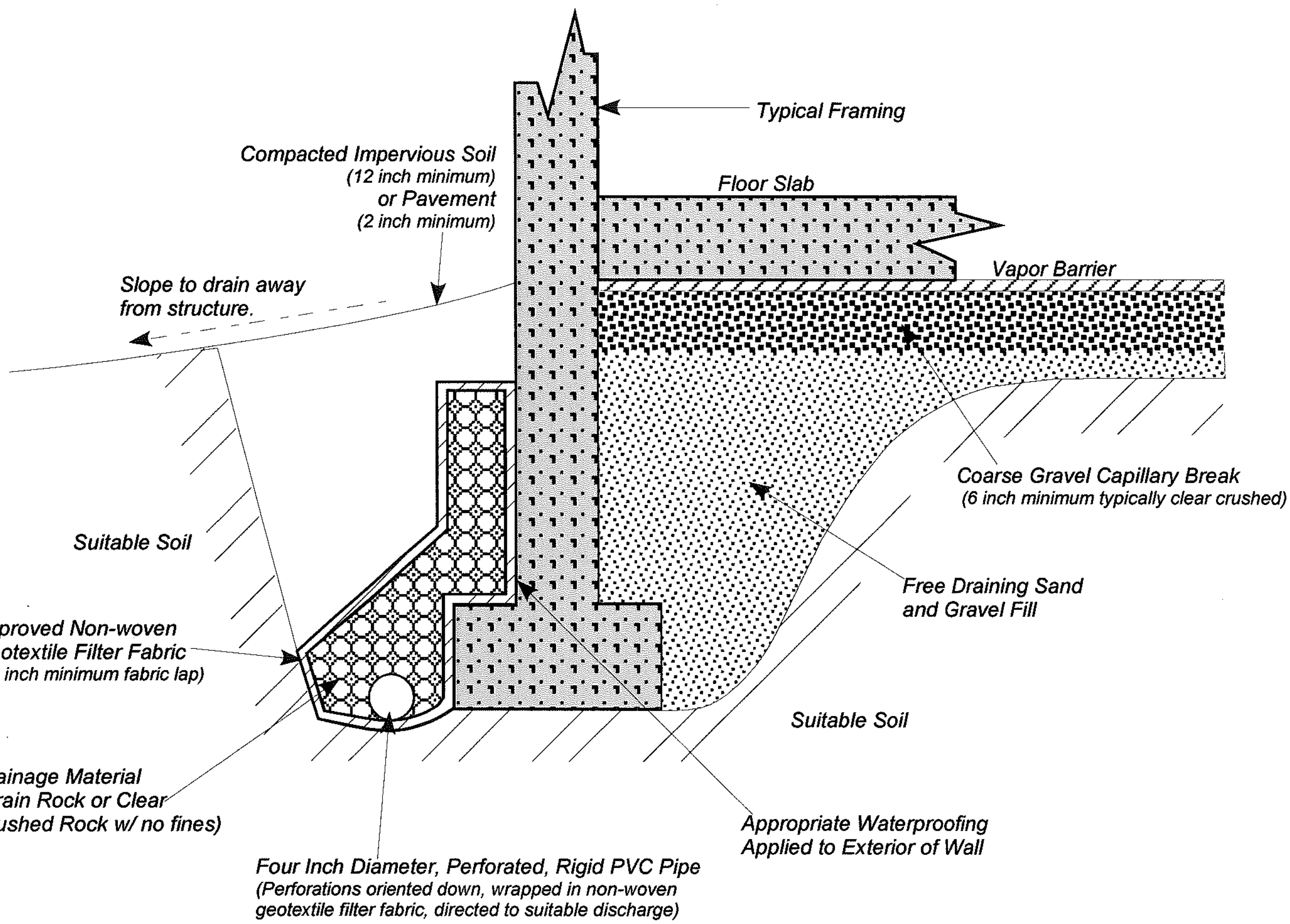


TP- # = Test Pit Exploration Location

Base Map by Harmsen & Associates, Inc. - dated 10-8-14

GEOTEST SERVICES, INC.	Date: 11-13-14	By: JB	Scale: None	Project 14-0577
741 Marine Drive Bellingham, WA 98225 phone: (360) 733-7318 fax: (360) 733-7418	**SITE AND EXPLORATION PLAN** **HAGER PROPERTY** **16691 CURRIE ROAD** **MONROE, WASHINGTON**			Figure 2

SHALLOW FOOTINGS WITH INTERIOR SLAB-ON-GRADE



Notes:

Footings Should be properly buried for frost protection in accordance with International Building Code or local building codes (Typically 18 inches below exterior finished grades)

The footing drain will need to be modified from this typical drawing to fit the dimensions of the planned monolithic footing and slab configuration

GEOTEST SERVICES, INC.
741 Marine Drive
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phone: (360) 733-7318
fax: (360) 733-7418

Date: 11-24-14	By: JB	Scale: None	Project
TYPICAL FOOTING & WALL DRAIN SECTION			**14-0577**
HAGER PROPERTY **16691 CURRIE ROAD** **MONROE, WASHINGTON**			Figure 3

Soil Classification System

MAJOR DIVISIONS			GRAPHIC SYMBOL	USCS LETTER SYMBOL	TYPICAL DESCRIPTIONS[1][2]
COARSE-GRAINED SOIL (More than 50% of material is larger than No. 200 sieve size)	GRAVEL AND GRAVELLY SOIL (More than 50% of coarse fraction retained on No. 4 sieve)	CLEAN GRAVEL (Little or no fines)		GW	Well-graded gravel; gravel/sand mixture(s); little or no fines
				GP	Poorly graded gravel; gravel/sand mixture(s); little or no fines
		GRAVEL WITH FINES (Appreciable amount of fines)		GM	Silty gravel; gravel/sand/silt mixture(s)
				GC	Clayey gravel; gravel/sand/clay mixture(s)
	SAND AND SANDY SOIL (More than 50% of coarse fraction passed through No. 4 sieve)	CLEAN SAND (Little or no fines)		SW	Well-graded sand; gravelly sand; little or no fines
				SP	Poorly graded sand; gravelly sand; little or no fines
		SAND WITH FINES (Appreciable amount of fines)		SM	Silty sand; sand/silt mixture(s)
				SC	Clayey sand; sand/clay mixture(s)
FINE-GRAINED SOIL (More than 50% of material is smaller than No. 200 sieve size)	SILT AND CLAY (Liquid limit less than 50)			ML	Inorganic silt and very fine sand; rock flour; silty or clayey fine sand or clayey silt with slight plasticity
				CL	Inorganic clay of low to medium plasticity; gravelly clay; sandy clay; silty clay; lean clay
				OL	Organic silt; organic, silty clay of low plasticity
	SILT AND CLAY (Liquid limit greater than 50)			MH	Inorganic silt; micaceous or diatomaceous fine sand
				CH	Inorganic clay of high plasticity; fat clay
				OH	Organic clay of medium to high plasticity; organic silt
	HIGHLY ORGANIC SOIL			PT	Peat; humus; swamp soil with high organic content

OTHER MATERIALS	GRAPHIC SYMBOL	LETTER SYMBOL	TYPICAL DESCRIPTIONS
PAVEMENT		AC or PC	Asphalt concrete pavement or Portland cement pavement
ROCK		RK	Rock (See Rock Classification)
WOOD		WD	Wood, lumber, wood chips
DEBRIS		DB	Construction debris, garbage

Notes: 1. Soil descriptions are based on the general approach presented in the *Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)*, as outlined in ASTM D 2488. Where laboratory index testing has been conducted, soil classifications are based on the *Standard Test Method for Classification of Soils for Engineering Purposes*, as outlined in ASTM D 2487.

2. Soil description terminology is based on visual estimates (in the absence of laboratory test data) of the percentages of each soil type and is defined as follows:

Primary Constituent:	> 50% - "GRAVEL," "SAND," "SILT," "CLAY," etc.
Secondary Constituents:	> 30% and ≤ 50% - "very gravelly," "very sandy," "very silty," etc.
	> 12% and ≤ 30% - "gravelly," "sandy," "silty," etc.
Additional Constituents:	> 5% and ≤ 12% - "slightly gravelly," "slightly sandy," "slightly silty," etc.
	≤ 5% - "trace gravel," "trace sand," "trace silt," etc., or not noted.

Drilling and Sampling Key

SAMPLE NUMBER & INTERVAL

- Sample Identification Number
- Recovery Depth Interval
- Sample Depth Interval
- Portion of Sample Retained for Archive or Analysis

1

SAMPLER TYPE

Code	Description
a	3.25-inch O.D., 2.42-inch I.D. Split Spoon
b	2.00-inch O.D., 1.50-inch I.D. Split Spoon
c	Shelby Tube
d	Grab Sample
e	Other - See text if applicable
1	300-lb Hammer, 30-inch Drop
2	140-lb Hammer, 30-inch Drop
3	Pushed
4	Other - See text if applicable

Groundwater

▽ ATD — Approximate water elevation at time of drilling (ATD) or on date noted. Groundwater levels can fluctuate due to precipitation, seasonal conditions, and other factors.

Field and Lab Test Data

Code	Description
PP = 1.0	Pocket Penetrometer, tsf
TV = 0.5	Torvane, tsf
PID = 100	Photoionization Detector VOC screening, ppm
W = 10	Moisture Content, %
D = 120	Dry Density, pcf
-200 = 60	Material smaller than No. 200 sieve, %
GS	Grain Size - See separate figure for data
AL	Atterberg Limits - See separate figure for data
GT	Other Geotechnical Testing
CA	Chemical Analysis

TP-1

SAMPLE DATA | **SOIL PROFILE** | **GROUNDWATER**

Excavation Method: Tracked Excavator
Ground Elevation (ft): Not Determined
Excavated By: Gillen Construction

Depth (ft)	Sample Number & Interval	Sampler Type	Test Data	USCS Symbol	Soil Description	Groundwater
0				OL	Soft, dark brown, wet, organic, sandy, SILT (Topsoil) (4" thick)	
	1	d	W = 11 GS	GP	Medium dense to dense, tan, moist, very sandy, fine to coarse GRAVEL (Alluvium) with numerous cobbles	
2	2	d	W = 21 GS	SP	Dense to very dense, tan grey, wet to saturated, fine to medium SAND (Alluvium)	Moderate groundwater seepage encountered at 2.0 ft.
4	3	d	W = 19 GS	GP/SP	Medium dense to very dense, tan grey, saturated, very gravelly, SAND to very sandy, GRAVEL (Alluvium) with reddish mottling from 3.5 to 4.5 feet BGS and trace cobbles	Rapid groundwater seepage encountered at 4.0 ft.
6	4	d				

Test Pit Completed 11/10/14
Total Depth of Test Pit = 7.0 ft.

TP-2

SAMPLE DATA | **SOIL PROFILE** | **GROUNDWATER**

Excavation Method: Tracked Excavator
Ground Elevation (ft): Not Determined
Excavated By: Gillen Construction

Depth (ft)	Sample Number & Interval	Sampler Type	Test Data	USCS Symbol	Soil Description	Groundwater
0	5	d	PP=2	OL	Soft, dark brown, wet, organic, sandy, SILT (Topsoil) (7" thick)	
	6	d	W = 26 GS	ML	Stiff, light grey, mottled, moist, very sandy, SILT (Alluvium)	
2	7	d	W = 7 GS	GW	Dense, grey tan, mottled, moist, well graded, very sandy, fine to coarse GRAVEL (Alluvium)	
	8	d	W = 19 GS	SP	Medium dense to dense, blue grey, slightly mottled, wet to saturated, fine to medium SAND (Alluvium)	Slight groundwater seepage encountered at 3.0 ft.
4	9	d		GP/SP	Medium dense to very dense, tan grey, saturated, very gravelly, SAND to very sandy, GRAVEL (Alluvium) with trace cobbles	
6						Rapid groundwater seepage encountered at 6.0 ft.

Test Pit Completed 11/10/14
Total Depth of Test Pit = 7.0 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

GEOTEST

Hager Property
16691 Currie Road
Monroe, Washington

Log of Test Pits

Figure 5

TP-3

SAMPLE DATA				SOIL PROFILE			GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Test Data	Graphic Symbol	USCS Symbol	Excavation Method: Tracked Excavator Ground Elevation (ft): Not Determined Excavated By: Gillen Construction	
0					OL	Soft, dark brown, wet, organic, sandy, SILT (Topsoil) (7" thick)	
	■	d			ML	Stiff, light tan, slightly mottled, wet, very sandy, SILT (Alluvium)	
2	■	d			GP/ SP	Medium dense to very dense, grey, wet to saturated, very gravelly, SAND to very sandy, GRAVEL (Alluvium) with heavy mottling in upper 1 to 2 feet and trace cobbles	∇ Slight groundwater seepage encountered at 3.0 ft. ∇ Rapid groundwater seepage encountered at 5.5 ft.

Test Pit Completed 11/10/14
Total Depth of Test Pit = 6.8 ft.

TP-4

SAMPLE DATA				SOIL PROFILE			GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Test Data	Graphic Symbol	USCS Symbol	Excavation Method: Tracked Excavator Ground Elevation (ft): Not Determined Excavated By: Gillen Construction	
0					OL	Soft, dark brown, wet, organic, sandy, SILT (Topsoil Fill) with wood and other debris	
2					OL	Medium stiff, dark grey brown, wet, slightly organic, sandy, SILT (Probable Relict Topsoil)	
	■	d			ML	Stiff, light grey, mottled, moist, very sandy, SILT (Alluvium)	
4	■	d			GP	Dense to very dense, tan, mottled, wet to saturated, very sandy, GRAVEL (Alluvium) with trace cobbles	∇ Rapid groundwater seepage encountered at 4.5 ft.
6					GP/ SP	Dense to very dense, grey, saturated, very gravelly, SAND to very sandy, GRAVE (Alluvium) with trace cobbles	

Test Pit Completed 11/10/14
Total Depth of Test Pit = 6.5 ft.

Notes: 1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

TP-5

Depth (ft)	Sample Number & Interval	Sampler Type	Test Data	Graphic Symbol	USCS Symbol	SOIL PROFILE	GROUNDWATER
						Excavation Method: Tracked Excavator Ground Elevation (ft): Not Determined Excavated By: Gillen Construction	
0					OL	Soft, dark brown, wet, organic, sandy, SILT (Topsoil) (8" thick)	
	■	d	PP=2.5		ML	Stiff, light grey, mottled, wet, very sandy, SILT (Alluvium)	
2	■	d			GP/ SP	Medium dense to very dense, tan, wet to saturated, very gravelly, SAND to very sandy, GRAVEL (Alluvium) with trace cobbles	∇ Slight groundwater seepage encountered at 2.5 ft.
4							∇ Rapid groundwater seepage encountered at 4.5 ft.
6							

Test Pit Completed 11/10/14
Total Depth of Test Pit = 6.0 ft.

TP-6

Depth (ft)	Sample Number & Interval	Sampler Type	Test Data	Graphic Symbol	USCS Symbol	SOIL PROFILE	GROUNDWATER
						Excavation Method: Tracked Excavator Ground Elevation (ft): Not Determined Excavated By: Gillen Construction	
0					OL	Soft, dark brown, wet, organic, sandy, SILT (Topsoil) (6" thick)	
	■	d	PP=2 W = 52 GS		ML	Stiff, dark grey, wet, sandy, SILT (Alluvium)	
2	■	d	PP=2.5 W = 31 GS		ML	Stiff, tan, mottled, wet, slightly sandy, SILT (Alluvium)	
	■	d	W = 9 GS		GP/ SP	Medium dense to very dense, tan, wet to saturated, very gravelly, SAND to very sandy, GRAVEL (Alluvium) with trace cobbles	
4							∇ Slight groundwater seepage encountered at 4.0 ft. ∇ Rapid groundwater seepage encountered at 5.0 ft.
6							

Test Pit Completed 11/10/14
Total Depth of Test Pit = 6.0 ft.

Notes: 1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

TP-7

SAMPLE DATA				SOIL PROFILE			GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Test Data	Graphic Symbol	USCS Symbol	Excavation Method: Tracked Excavator Ground Elevation (ft): Not Determined Excavated By: Gillen Construction	
0					OL	Soft, dark brown, wet, organic, sandy, SILT (Topsoil) (6" thick)	
					ML	Stiff, light grey, mottled, wet, very sandy, SILT (Alluvium)	
		d	W = 21 GS		SP-SM	Medium dense to dense, mottled tan, moist, slightly silty, SAND (Alluvium)	
2		d			SP	Dense to very dense, grey, mottled, wet to saturated, SAND (Alluvium)	Slight groundwater seepage encountered at 2.5 ft.
					GP	Dense to very dense, tan grey, heavily mottled, wet to saturated, very sandy, GRAVEL (Alluvium)	
4					SP	Dense to very dense, grey, saturated, SAND (Alluvium) with significant caving/running	Rapid groundwater seepage encountered at 4.0 ft.
6					GP	Dense to very dense, grey, saturated, very sandy, GRAVEL (Alluvium) with trace cobbles	

Test Pit Completed 11/10/14
Total Depth of Test Pit = 6.5 ft.

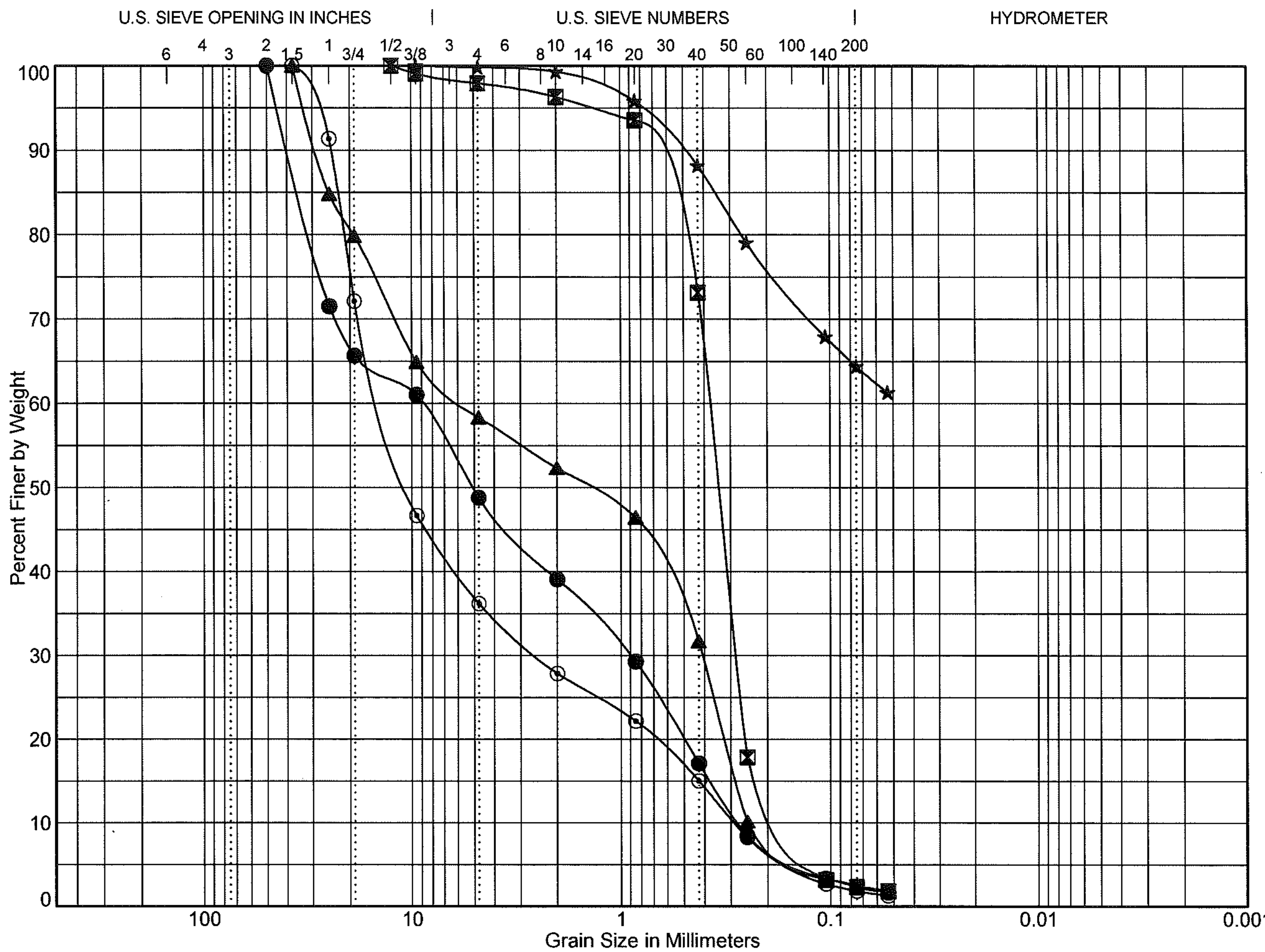
TP-8

SAMPLE DATA				SOIL PROFILE			GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Test Data	Graphic Symbol	USCS Symbol	Excavation Method: Tracked Excavator Ground Elevation (ft): Not Determined Excavated By: Gillen Construction	
0					OL	Soft, dark brown, wet, organic, sandy, SILT (Topsoil) (8" thick)	
					ML	Stiff, dark grey, wet, sandy, SILT (Alluvium)	
					ML	Stiff, tan, mottled, wet, slightly sandy, SILT (Alluvium)	
2		d			GP/SP	Medium dense to very dense, tan grey, wet to saturated, very gravelly, SAND to very sandy, GRAVEL (Alluvium) with trace cobbles and mottling in upper 1 foot Slightly mottled tan horizon at 4.5 feet BGS	Slight groundwater seepage encountered at 2.5 ft. Moderate groundwater seepage encountered at 5.0 ft.

Test Pit Completed 11/10/14
Total Depth of Test Pit = 7.0 ft.

Notes: 1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

GEOTEST	Hager Property 16691 Currie Road Monroe, Washington	Log of Test Pits	Figure 8



Cobbles	Gravel		Sand			Silt or Clay
	coarse	fine	coarse	medium	fine	

Point	Depth	Classification	LL	PL	PI	C_c	C_u
● TP-1	1.0	Very sandy, fine to coarse GRAVEL (GP)				0.33	32.60
⊠ TP-1	2.0	Fine to medium SAND (SP)				1.34	2.38
▲ TP-1	3.5	Very gravelly, fine to coarse SAND (SP)				0.12	23.02
★ TP-2	0.5	Very sandy, SILT (ML)					
⊙ TP-2	1.5	Very sandy, fine to coarse GRAVEL (GW)				1.60	47.58

Point	Depth	D_{100}	D_{60}	D_{50}	D_{30}	D_{10}	%Coarse Gravel	% Fine Gravel	% Coarse Sand	% Medium Sand	% Fine Sand	% Fines
● TP-1	1.0	50	8.962	5.084	0.905	0.275	34.3	16.9	9.7	22.0	14.7	2.4
⊠ TP-1	2.0	12.5	0.375	0.34	0.281	0.157	0.0	2.1	1.6	23.1	70.9	2.3
▲ TP-1	3.5	37.5	5.662	1.426	0.407	0.246	20.1	21.5	6.0	20.6	29.2	2.5
★ TP-2	0.5	9.5					0.0	0.2	0.5	11.1	23.8	64.4
⊙ TP-2	1.5	37.5	13.657	10.4	2.501	0.287	27.9	35.9	8.4	12.8	13.2	1.8

$C_c = D_{30}^2/(D_{60} * D_{10})$ To be well graded: $1 < C_c < 3$ and

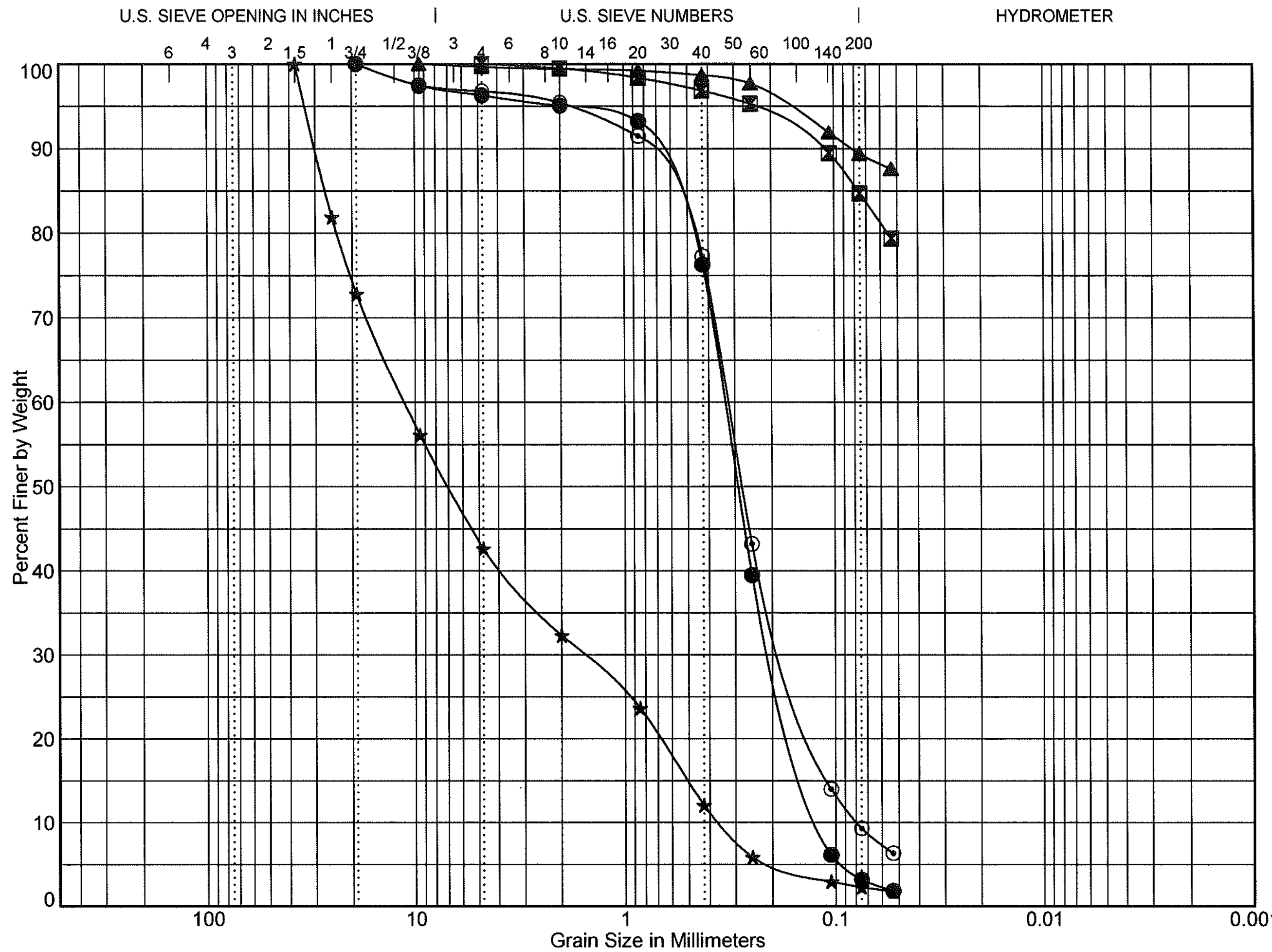
$C_u = D_{60}/D_{10}$ $C_u > 4$ for GW or $C_u > 6$ for SW

GEOTEST

Hager Property
16691 Currie Road
Monroe, Washington

Grain Size Test Data

Figure 9



Cobbles	Gravel		Sand			Silt or Clay
	coarse	fine	coarse	medium	fine	

Point	Depth	Classification	LL	PL	PI	C_c	C_u
● TP-2	2.8	Fine to medium SAND (SP)				0.98	2.89
⧗ TP-6	0.5	Sandy, SILT (ML)					
▲ TP-6	1.5	Slightly sandy, SILT (ML)					
★ TP-6	3.0	Very sandy, fine to coarse GRAVEL (GP)				0.64	31.30
⊙ TP-7	1.3	Slightly silty, fine to medium SAND (SP-SM)				1.11	4.12

Point	Depth	D_{100}	D_{60}	D_{50}	D_{30}	D_{10}	%Coarse Gravel	% Fine Gravel	% Coarse Sand	% Medium Sand	% Fine Sand	% Fines
● TP-2	2.8	19	0.336	0.291	0.195	0.116	0.0	3.7	1.2	18.8	73.1	3.2
⧗ TP-6	0.5	4.75					0.0	0.0	0.5	2.6	12.1	84.7
▲ TP-6	1.5	9.5					0.0	0.3	0.3	0.7	9.3	89.4
★ TP-6	3.0	37.5	11.158	6.935	1.593	0.357	27.2	30.2	10.3	20.2	9.8	2.3
⊙ TP-7	1.3	19	0.325	0.278	0.169	0.079	0.0	3.2	1.4	18.1	68.0	9.3

$C_c = D_{30}^2/(D_{60} * D_{10})$ To be well graded: $1 < C_c < 3$ and

$C_u = D_{60}/D_{10}$ $C_u > 4$ for GW or $C_u > 6$ for SW

14-0577 12/1/14 C:\USERS\JUSTIN\DESKTOP\JOB FILES\14-0577 - HAGER PROPERTY\14-0577 - HAGER PROPERTY.GPJ GRAIN SIZE W/STATS

GEOTEST

Hager Property
16691 Currie Road
Monroe, Washington

Grain Size Test Data

Figure
10

Northwest Agricultural Consultants
2545 West Falls
Kennewick, WA 99336
(509) 783-7450 Fax: (509) 783-5305

PAP-Accredited
NAPT
2014

GEOTEST SERVICES INC
741 MARINE DR
BELLINGHAM, WA 98225

SOIL
Client No.: 9678 Date Received: 12-01-2014
Report No.: 33644 Page: 1 of 1
f39390-89904

Grower	Sampler	Field No.	Field Name	Crop Year	Crop	Yield Goal
		Job # 14-0577	**Hager Property**			

Depth (ft.)	Available Inches	NO3-N lbs/acre	NH4-N lbs/acre	Sulfur ppm	pH	Soluble Salts (mmhos /cm)	Organic Matter Percent	P(bic) ppm	K(bic) ppm	P(ace) ppm	K(ace) ppm	Calcium (meq. per 100 grams)	Magne-sium (meq. per 100 grams)	Sodium (meq. per 100 grams)	Eff.	Boron ppm	Zinc ppm	Manga-nese ppm	Iron ppm	Copper ppm	CEC (meq. per 100 grams)	% Base Sat.	Chloride lbs. per. acre	Bray 1P ppm	Total Bases (meq. per 100 grams)	SampleID
1					5.7																7.8					
2					5.3																7.4					
Total	0.00																									

Estimated Nitrogen Release from Organic Matter

Estimated Total Nitrogen Available to Crop

Last Year's Crop

Fertilizer

Comments

Sample ID	pH	Loss on Ignition OM	Cation Exchange Capacity
HAG-2-1.5	5.7	1.95%	7.8 meq/100g
HAG-7-1.25	5.3	2.52%	7.4 meq/100g

CEC EPA Method 9081